Advanced Reactor Technologies

California Council on Science and Technology
Sacramento

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Deputy Associate Laboratory Director for Nuclear Programs
Idaho National Laboratory
&
Vice President / President-Elect
American Nuclear Society

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International nuclear electric production

	Number	% CF	% of Total Generation
United States	103	92	20
France	59	88	78
Japan	52	70	25
Russia	30	68	17
Canada	21	64	13
South Korea	20	92	40
China	9	84	2
Taiwan	6	88	22
Mexico	2	79	5

International ranking of nuclear capacity as percentage of total electrical production

Country	% of Nuclear Power to Total Output
Lithuania	80
France	78
Slovakia	57
Belgium	55
Sweden	50
Ukraine	46
South Korea	40
Slovenia	40
Switzerland	40
Bulgaria	38
Armenia	35
Hungary	33
Czech Republic	31
Germany	28
Finland	27
Japan	25
Spain	24
U.K.	24
Taiwan	22
U.S.A.	20

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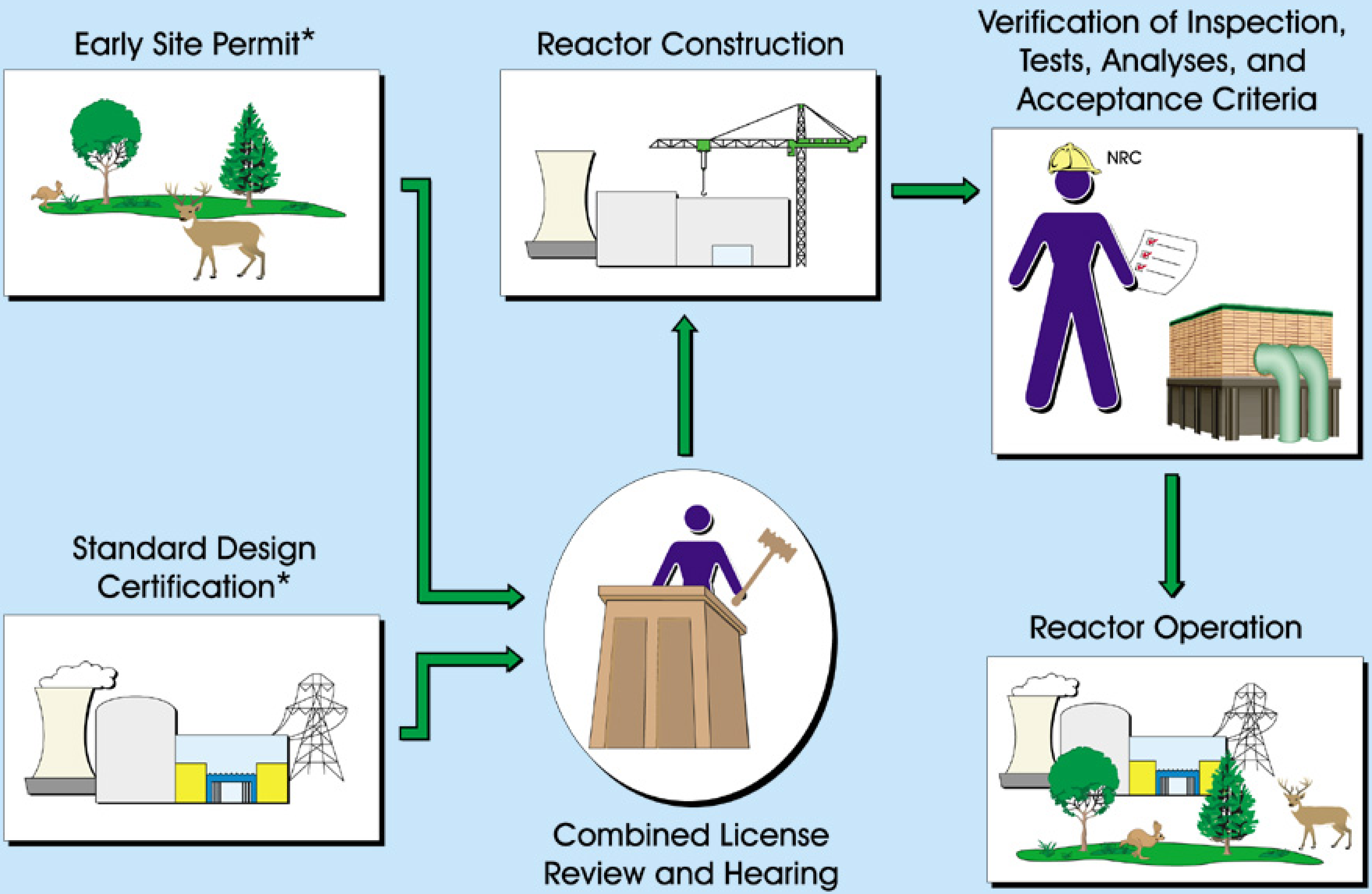
Current unit expansion in Asia/Europe

Country	Operating Units	Number of Units Under Construction	Near-Term Plan (GWe)	By (year)
India	14	8	29.5	2022
South Korea	20	6	26.6	2015
Russia	30	4	40	2020
Japan	52	3	15	2025
China	9	2	40	2020
Ukraine	8	2	22	2030
Pakistan	2	—	8.5	2030
Iran	0	1	—	—
Romania	1	1	—	—
Finland	4	1 28	— 160	—

The Energy Policy Act of 2005

- Includes incentives for new nuclear plants
- Industry has responded with expressions of interest in 17 new nuclear reactors

Combined Licenses, Early Site Permits, and Standard Design Certifications

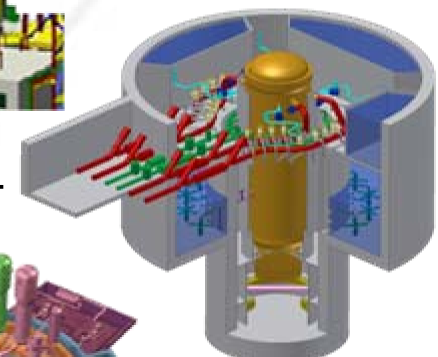


* or equivalent process

New designs available today—*Generation III*+

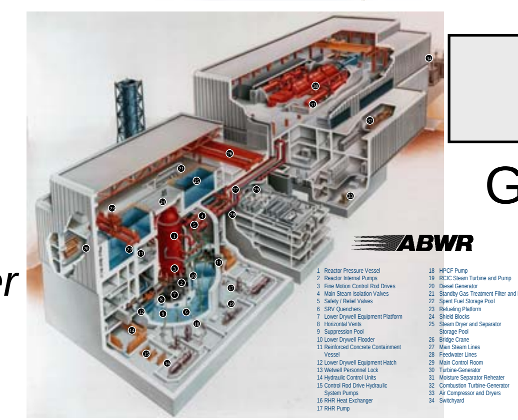
Advanced Light Water Reactors (ALWRs)

- Standardized designs based on modularization producing shorter construction schedules
- Passive or redundant systems to enhance safety
- Easier to protect from terrorist attacks



Gen-III+

further evolution



ABWR
Advanced Boiling Water Reactor

Gen-III

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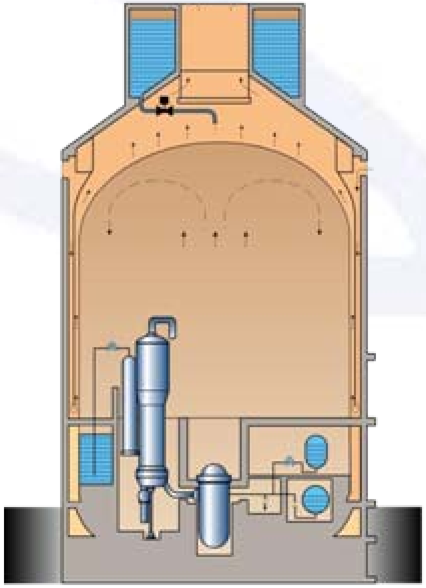
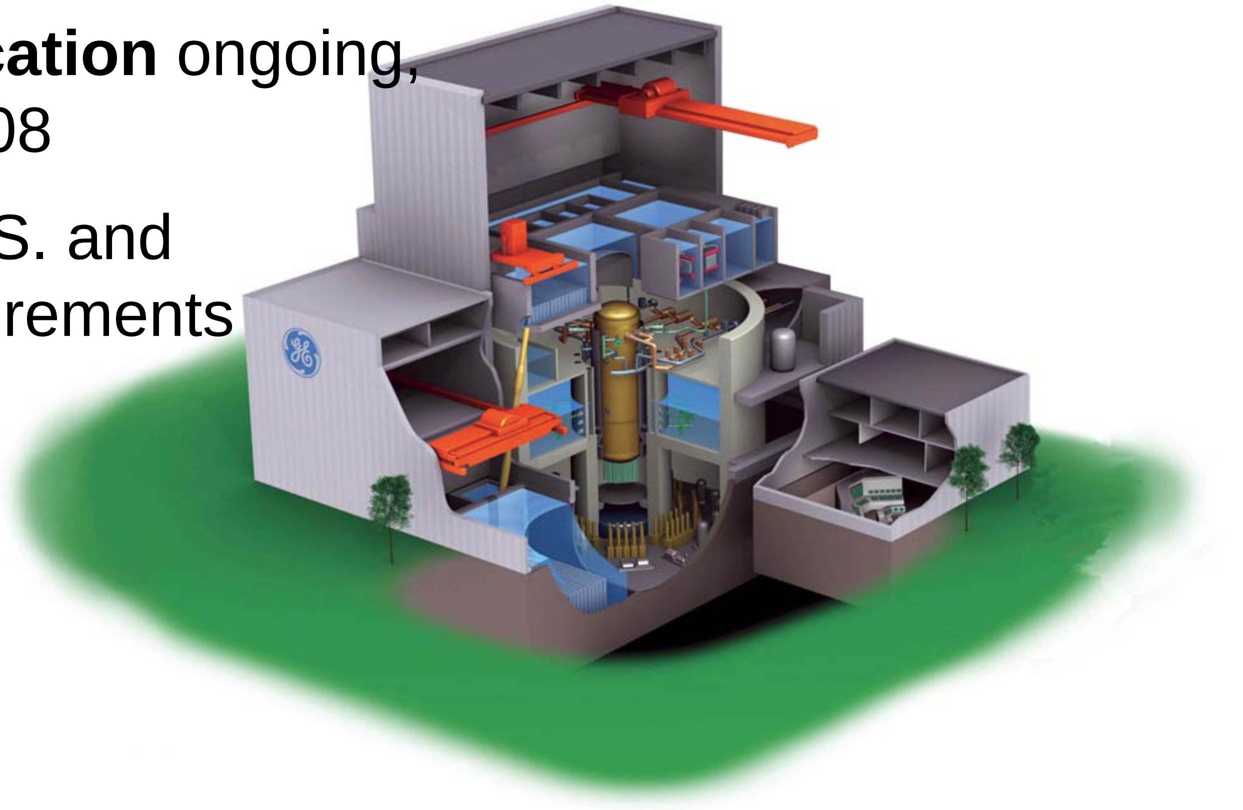
Westinghouse

- **AP 1000 (1,148 MWe)**
  - Passive safety systems
  - **NRC design certification** provides regulatory certainty:
    - AP 600—Approved December 1999
    - AP 1000—Approved early 2006



General Electric

- **Economic Simplified Boiling Water Reactor ESBWR (1,550 MWe)**
  - Passive safety systems
  - **Design certification** ongoing, expected in 2008
  - Designed to U.S. and European requirements



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AREVA/Framatome ANP

- **Evolutionary Power Reactor EPR (1,600 MWe)**
  - Redundant safety systems
  - Preparing for certification
  - European version under construction in Finland
  - **Design certification** review to start in 2007; completion estimated in 2010

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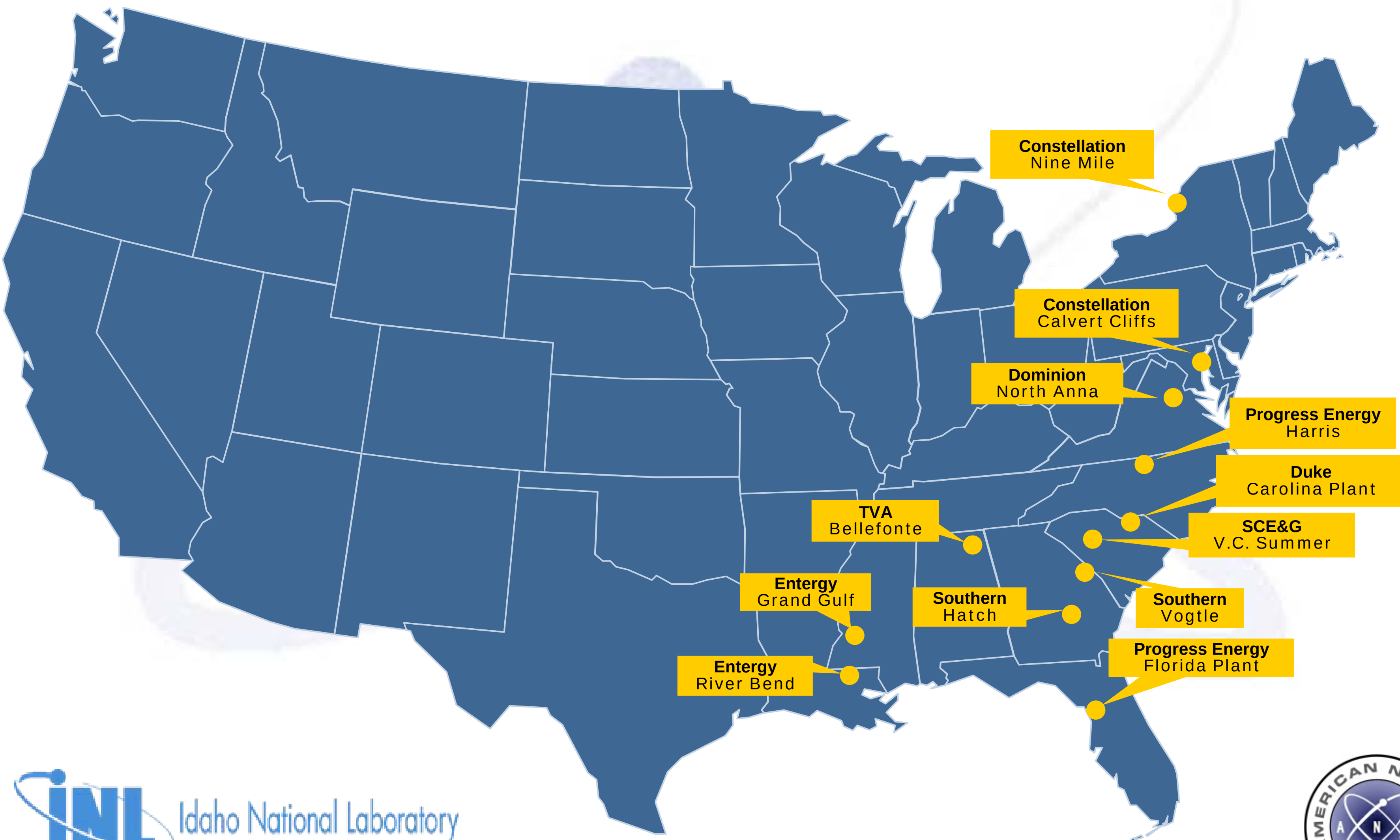
First movers for new nuclear plants



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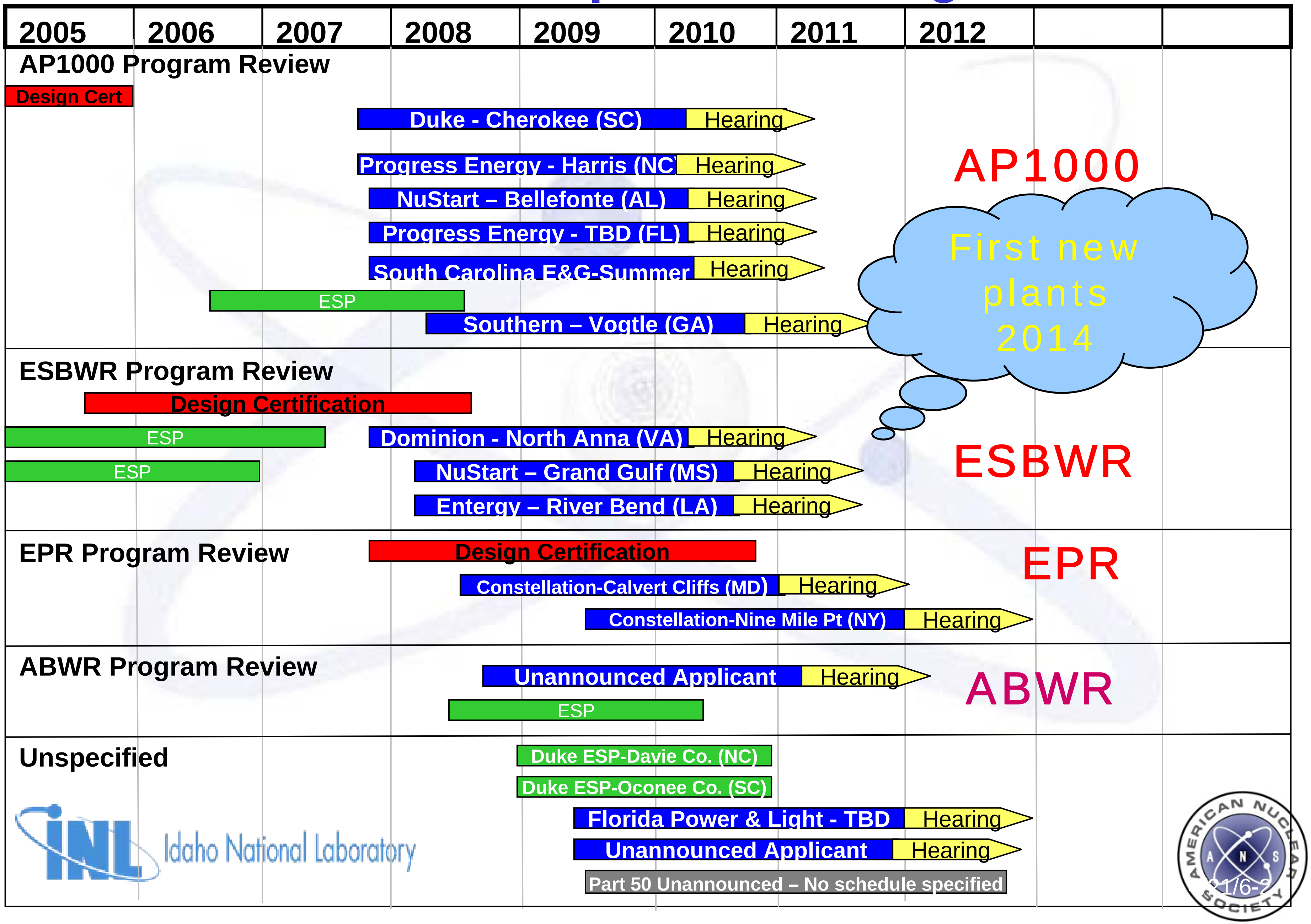
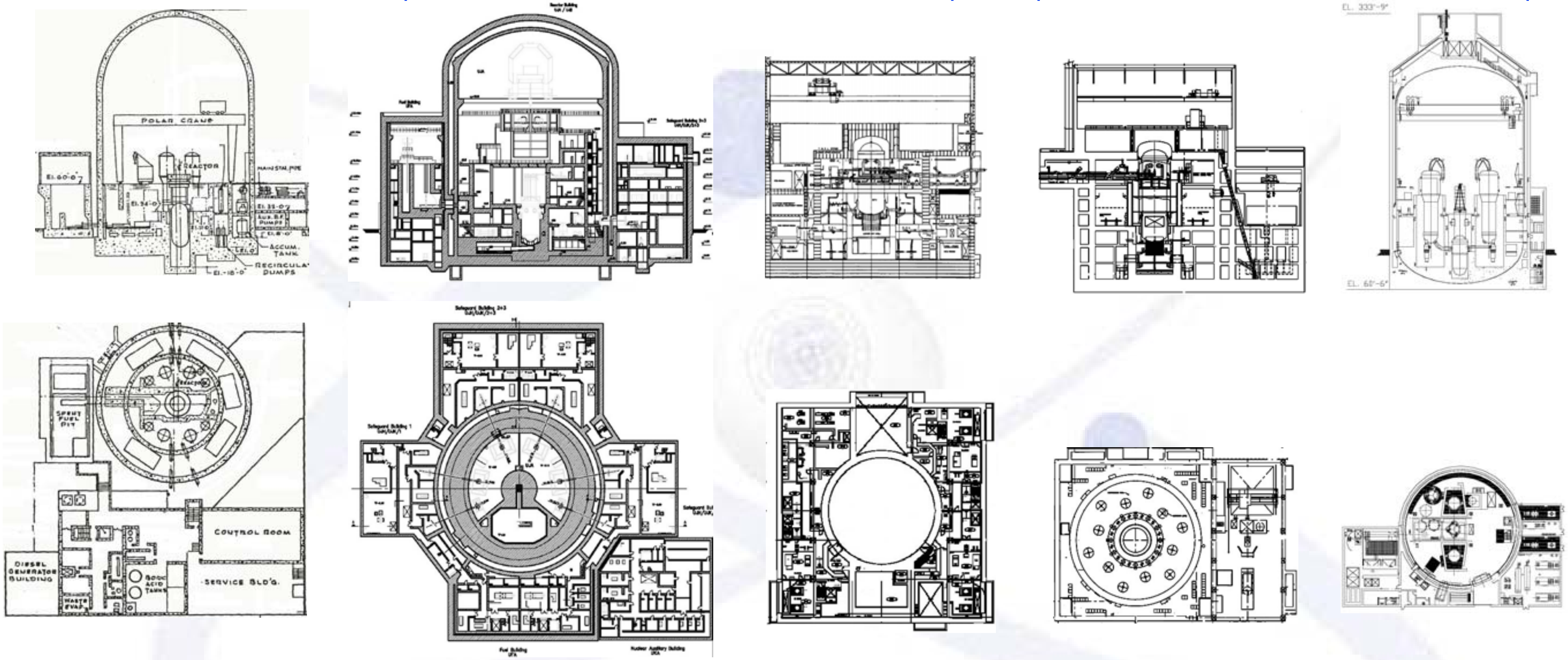
NRC’s etimate of new plant licensing schedule



The new ALWR designs reverse the trend of increasing steel and concrete

Gen II | **Gen III - Active** | **Gen III+ - Passive**



1970's PWR	EPR	ABWR	ESBWR	AP-1000
1000 MWe	1600 MWe	1380 MWe	1550 MWe	1090MWe
40 MT_{steel}/MW	49 MT_{steel}/MW	51 MT_{steel}/MW	__ MT_{steel}/MW	42 MT_{steel}/MW

Scaled Comparison

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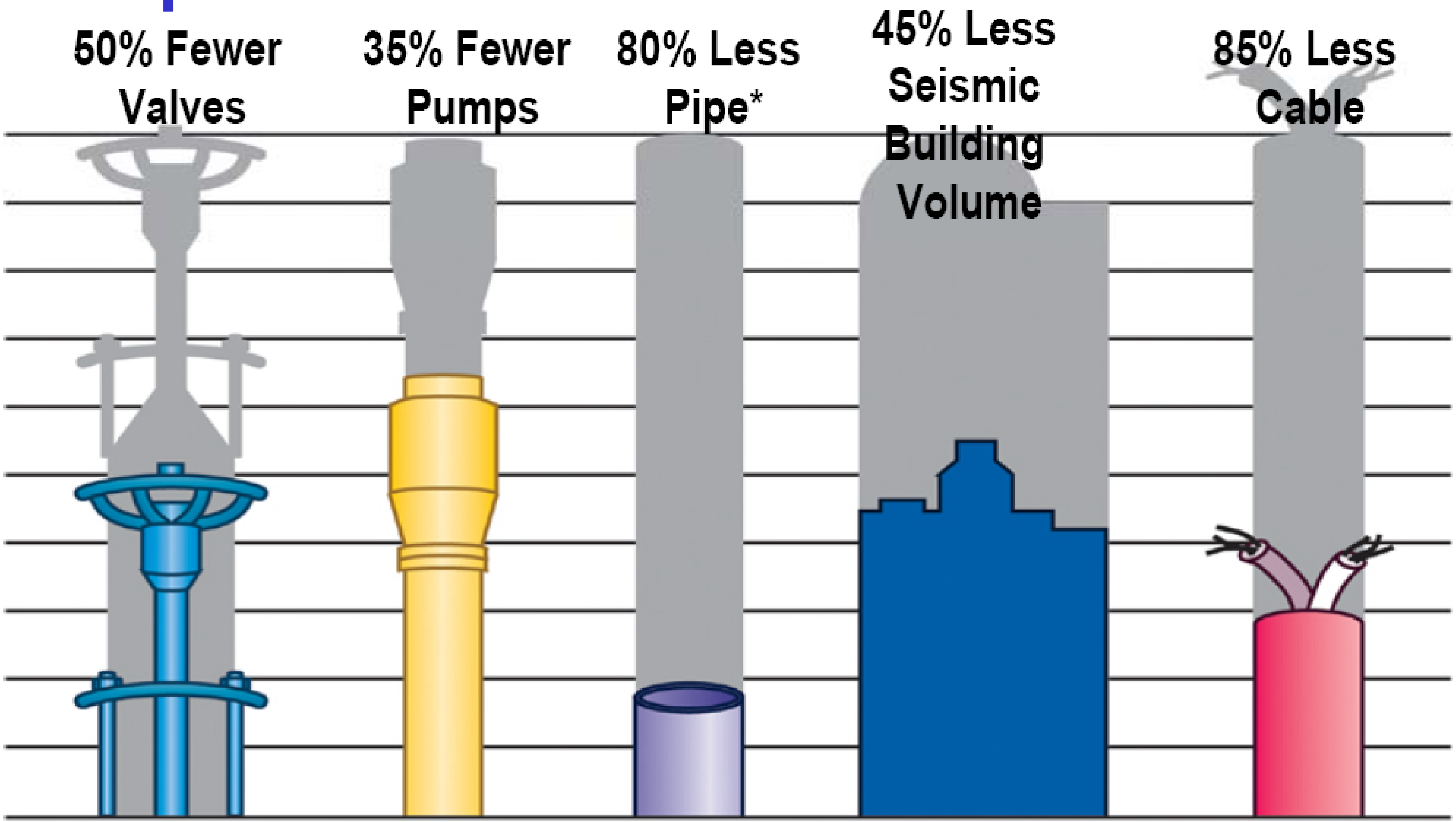
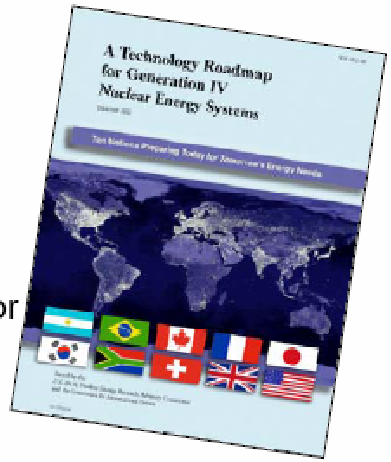
AP-1000 has large reduction in components



Sue Ion, GLOBAL 2005

Generation IV Initiative – Mission

- **International initiative under DOE leadership**
  - DOE and other countries to plan next-generation nuclear technology R&D collectively.
  - Governed by Gen IV International Forum (GIF)
- **Vision**
  - Develop advanced nuclear technologies for deployment by 2030 in collaboration with GIF partners
- **Forward-looking technology goals established**
  - Economics, safety, waste/sustainability, proliferation resistance and physical protection
- ***Gen IV Roadmap***
  - Identified fuel cycles and reactors to advance goals and serve future energy markets



- **GIF selected 6 concepts as most-promising**

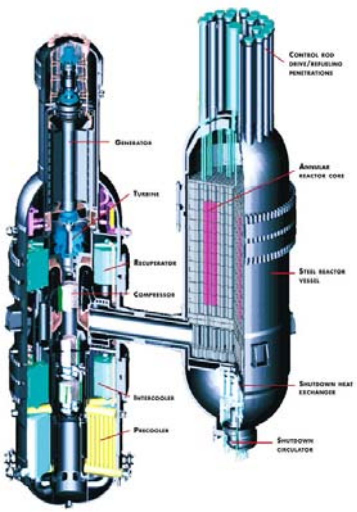
GFR -- Gas-cooled fast reactor
VHTR -- Very high temperature reactor
SCWR -- Supercritical water-cooled reactor
LFR -- Lead-cooled fast reactor
SFR -- Sodium-cooled fast reactor
MSR -- Molten salt reactor

- **U.S. now focused on Very-High-Temperature Reactor (VHTR) and Sodium Fact Reactor (SFR)**

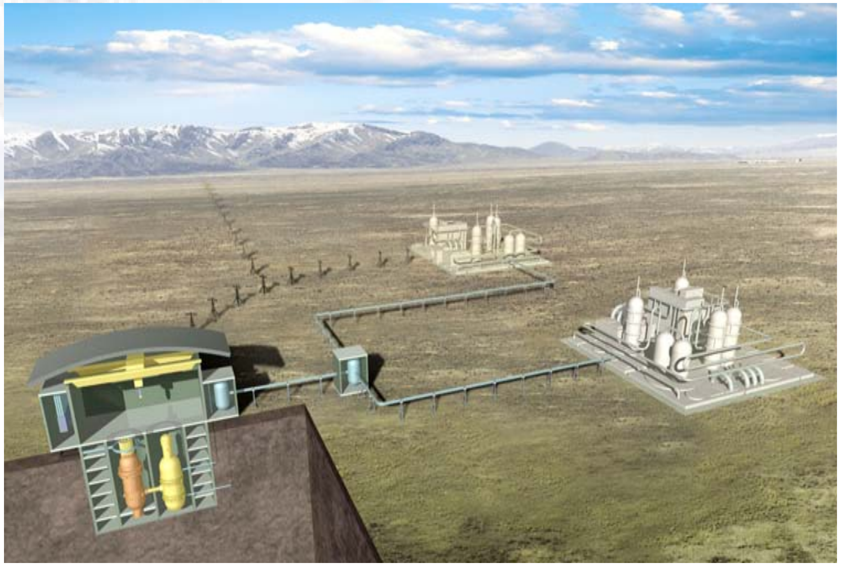
High-temperature Gen IV reactors may have multiple applications

PBMR
165 MWe

- NGNP technology not fixed until 2011
- Strategy due to Congress 8/8/08
- Idaho National Laboratory to provide support
- Flexible licensing strategy



GT-MHR
286 MWe



Next Generation Nuclear Plant (NGNP)

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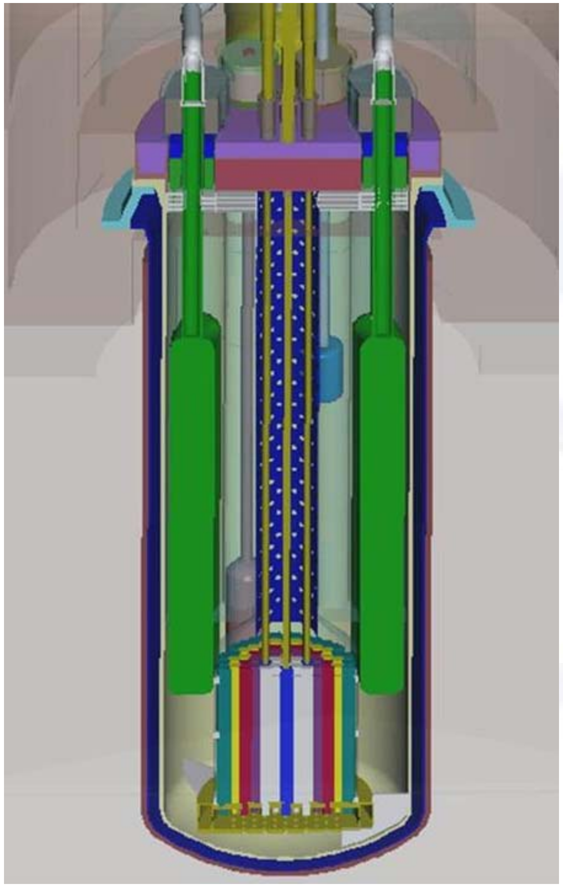
Sodium fast reactor development targets spent fuel management



R & D Objectives

- 200-MWt demonstration burner
- Cost reduction design features
- Co-located with processing facility
- Fuels and safety testing capability

Demonstration Focus Areas

- Prototypical recycled fuel
- Verification of safety performance
- Remote handling refueling equipment
- Economics for deployed power reactors

Phillip Finck, ANL

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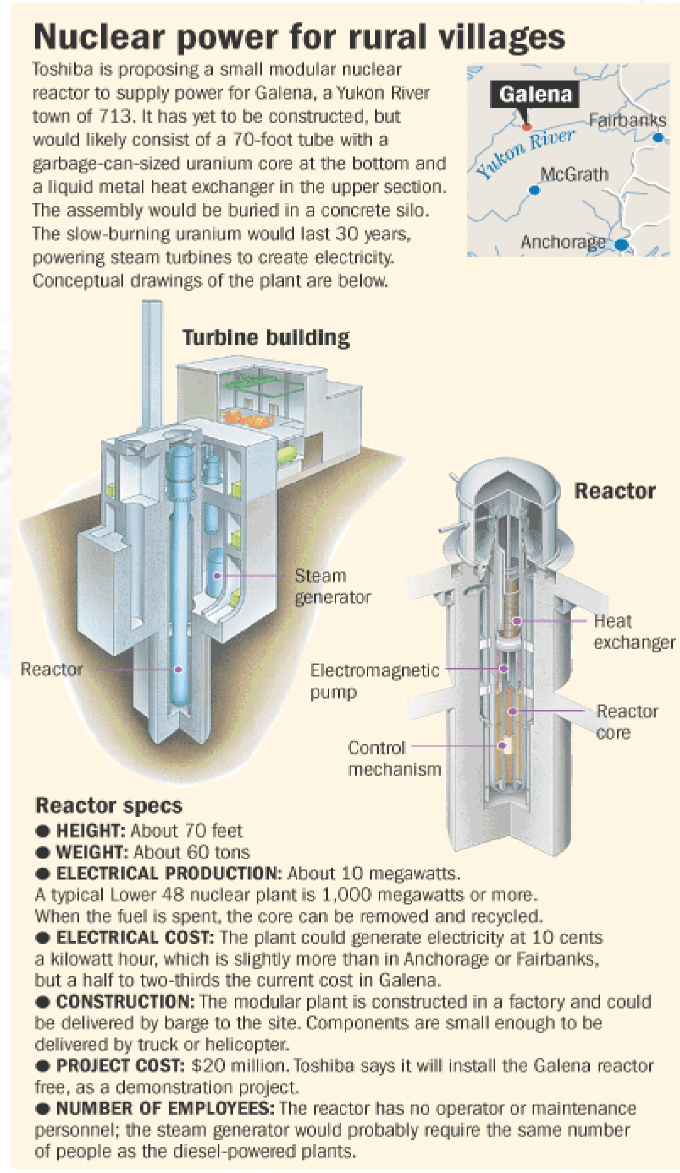
Toshiba 4S sodium cooled reactor targets small niche markets

- **10 MWe**
- Designed for remote locations without much infrastructure
- **No refueling over 30 year lifetime**
- Reactivity control – movable reflectors
- Passive safety
- **NRC pre-application review pending**
- Galena, Alaska?



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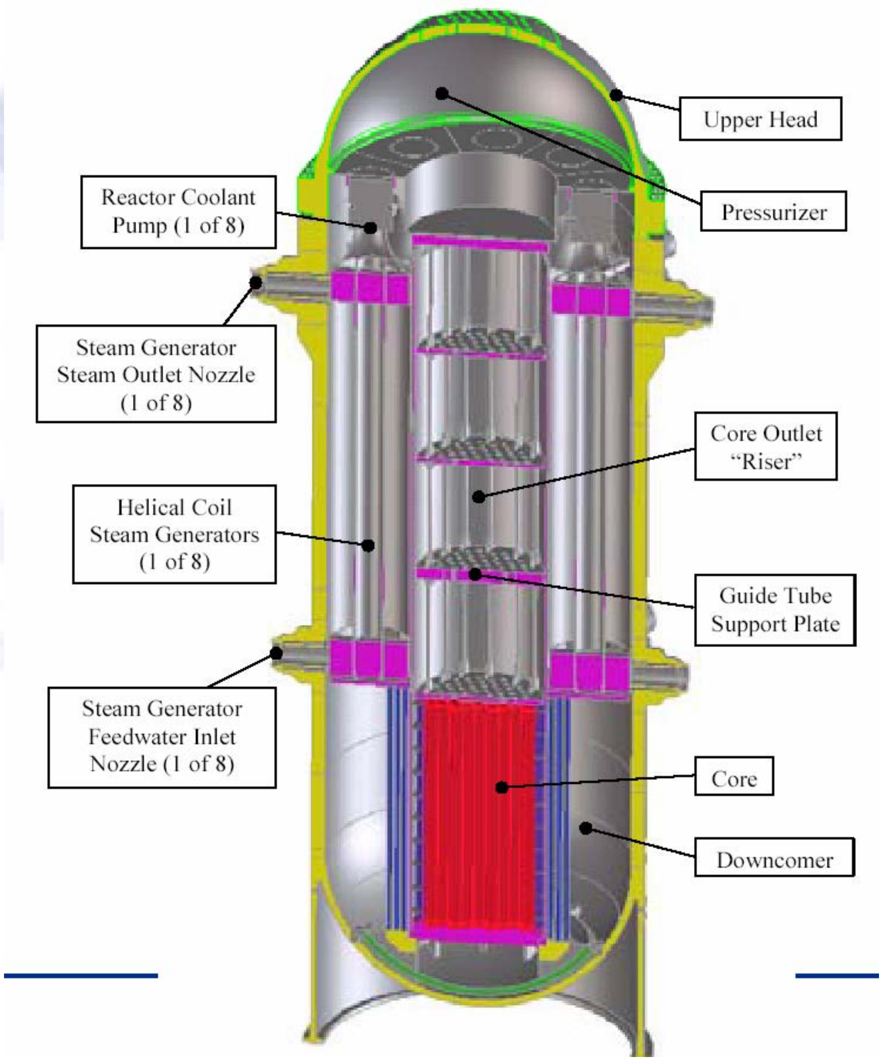
[Westinghouse] International Reactor Innovative and Secure (IRIS)

- Integral LWR (335 MWe)
- Safety by innovative design features and passive safety systems
- 3 - 4 year core
- Modular fabrication and construction
- Spherical Containment
- Generation IV Objectives
  - Proliferation Resistance
  - Enhanced Safety
  - Improved Economics
  - Reduced Waste
- **NRC pre-application review underway**



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